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Buckling Characteristics Analysis of a Cold-Formed Steel HS 75 with Diaphragm Plates Attachment

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ABSTRACT

The purpose of this study is to analyze the increase of strength in buckling phenomenon with the addition of a diaphragm plate on a HS-75 profile moreover the other objective is to gain an understanding of the analytical optimization of the diaphragm plate.
In this study the material used is a HS-75 0.80 mm profile. While the equipment used in this study is a set of a compression test tool *(buckling test).*
The results shows that the maximum load occurs in a HS-75 profile mild steel material with a three diaphragms attached are about 26780 N, about 18495 N for one diaphragm attached and 17360 N for the profile without any diaphragm attached. This is an indication that the profile with a three diaphragm attached was able to withstand the maximum load greater than either the profile attached with one diaphragm or the profile without any diaphragm attached. Apart from that the stress occurs in the profile with the three diaphragms plates attached is bigger than the stress occurs in the profile with one diaphragm plate attached and of course bigger than the stress occurs on the profile without any diaphragm plate attachment. The stress occurs in the three diaphragm plate attached is about 139.99 MPa , and 96.68 MPa for the one diaphragm plate attached and finally 90.75 MPa for the profile without any diaphragm attachment.

INTRODUCTION

Thin steel is a type of steel that has a relatively thin but has a big ratio between the width and thickness profile dimension. Cold formed steel or more familiarly called as mild steel is a sort of steel plate that is cold formed in such a way (atmospheric temperature).

Roof truss design with lightweight steel material is basically the same as the roof truss design with other materials. The design principle is how to select the profile that has a larger capacity than the rod force that occurs without ignoring the economic level of the structure itself. For a lightweight steel design, which is formed from a thin plate with a thickness ranges of 0.73 mm to 1 mm, this led to the behavior of the material if the material having a pressure load then the material will be prone to buckling and when the material having a tensile load then the joint, which is weakest part, will be broken. So the main objective of this design review is to select a profile that has the capacity to accommodate these weaknesses.

A rod will buckle under a pressure both from the x-axis cross-section direction (lateral buckling), from the y-axis direction (local buckling), and torque (torsional buckling). Thus, in the analysis, the profile designed should be able to withstand the force that resulted in these three types of buckling. If the cross sectional area capacity does not meet any of these buckled bend over, then on the rod can be add some strengthening elements that can increase the rod strength. So that the rod can withstand all the type of buckling occurs.

Research on the light steel profile continues to get the best profile strength and rigidity. To reduce the local buckling, an intermediate stiffener was used to strengthen the cold formed steel profile, based on the cross-sectional profile. Some profile models used in Indonesia are: the C-Sections, the Hat Sections (HS), the Z-sections, the I-sections and the T sections.

This Research will focus on one of the profile models, which is the Hat-Sections Profile. This profile was developed, because it has a stronger structure compare with the C-sections profile. HS-75 was introduced as an alternative material for truss structural system. This profile material is layer coated with zinc composition of 6% aluminum, 3% Magnesium, and Zg-90 (140 gr/m^2). This profile has a thin and lightweight characteristic of steel but has a function equivalent with conventional steel. Hat-sections were created to facilitate the ease assembly and construction. Although it is thin, the tensile strength is up to 550 MPa (Rogers, et al, 2006).

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The HS-75 profile usefulness on the steel truss structure system is due to its reliability. This product is expected to fulfill the need of an alternative building component. To determine the HS-75 profile reliability in a truss structure, it is necessary to study deeper about the strength and flexural profile HS-75 with a Diaphragm Plate as a stiffener attached on the profile (Desmond, Pekoz, and Winter, ASCE, 1981).

By attaching a Diaphragm Plate (intermediate stiffener) at a particular position along the rod will increase the profile properties close to or equal to the timber strength. According to investigations conducted by The Network Information Center of Science and Technology (BPPT), the light steel structure damage mechanism, it is found that there are two different damage mechanism models. The first model is the concentrated compressive load interaction and the bending moment. Whereas for the second model is the axial compressive load. These two models would be the basis of using the rigid plastic mechanism for the development of plastic analysis theory. (Setiyono 2008).

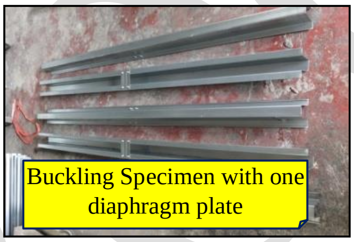
The use of mild steel has been very broad in the community. It is expected that the HS-75 profile buckling test results for the HS-75 profile without any diaphragm plate and the HS-75 profile with a diaphragm plate attached would give a positive result so that everyone could get the HS-75 profile strength information. Research should also continue to be done to calculate the elastic buckling, the effective width and the longitudinal stiffeners (Schafer, Pekoz, 2006).

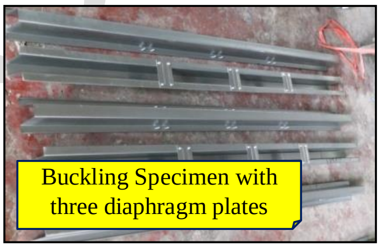
This research is examining the HS-75 profile with a ZAM layered. HS-75 profile is implemented as an axial tensile beam or as axial pressure beam of a roof frame.

Goals to be achieved, in this HS-75 profile research is to find out the profile strength increase if the profile is attaching with a diaphragm plate, and gain an optimization analysis understanding of using the diaphragm plate towards the bending forces.

2. Research Method

The object of this research is a HS-75 profile with a thickness of 0,80 mm as shown in Figure 1 below:





HAT SECTION (HS-75 PROFILE)

Hat section profile (HS-75) was used as roof truss rod (beam) to replace timber and also used as an axial push / pull roof frame truss rod.HS-75 profile can be seen in Figure1.below:

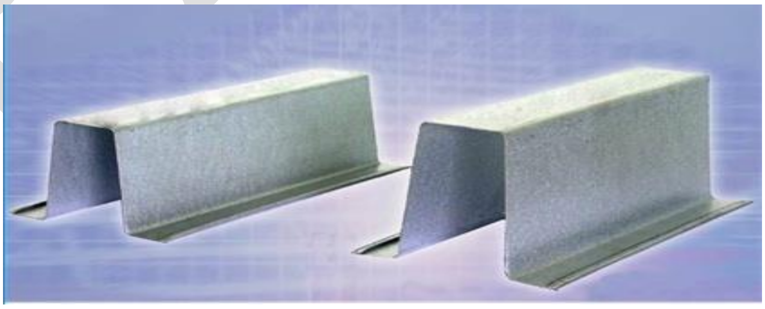


Figure 1. HS-75 profile with a 0.80 mm thickness (Source: Renansiva, 2003)

The HS-75 profile dimensions can be seen in Figure 2. Below:

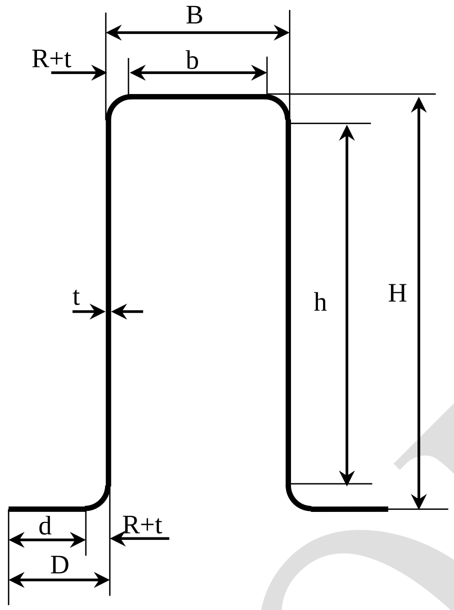


Figure 2. HS-75 profile Dimension (Source: Jaindo Metal Industries 2009, Renansiva, 2003)

HS-75 profile properties data can be seen in table. 1 below:

Table 1. HS-75 profile properties data (Jaindo Metal Industries, 2009).

Profile type	H (mm)	h(mm)	B(mm)	W(mm)	R(mm)	D(mm)	d(mm)	t(mm)
HS-75; 0.8	75	70.22	40	35.22	1.59	25	22.61	0.80
HS-75; 0.5	75	70.82	40	35.82	1.59	25	22.91	0.50

Table 2..HS-75 profile, full section properties(Jaindo Metal Industries, 2009).

Profile type	F_y (MPa)	E(MPa)	G(MPa)	A_f(mm^2)	Mass(kg/m)	I_x(mm^4)	S_x(mm)
HS-75; 0.8	550	203550	77970	186.70	1.47	147500	3773
HS-75; 0.5	550	203550	77970	117.42	0.92	93680	2397

Table3. HS-75 profile, full section properties (Continued)

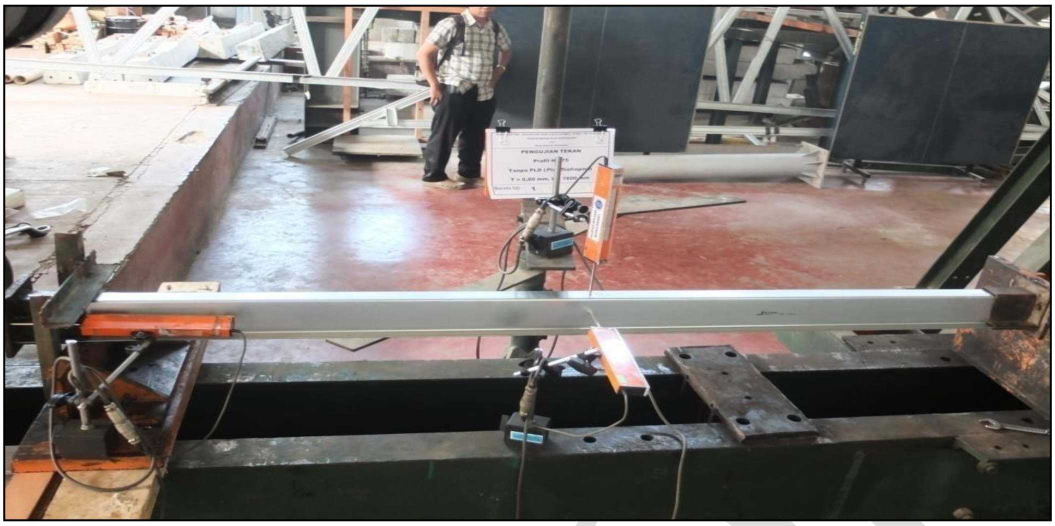
Profile type	r_x (mm)	I_y(mm^4)	S_y(mm^3)	r_y(mm)	J(mm^4)	C_w(mm^6)	r_o(mm)
HS-75; 0.8	28.11	90610	2050	22.03	40.41	1.73 E+08	72.42
HS-75; 0.5	28.25	57810	1299	22.19	39.92	1.73 E+08	72.42

The equipment used in this research is as follows:

a. A set of *buckling test equipment.*
b. *Linear Variable Differential Transducers* as a measure tool to detect the object deflection.
c. *Strain Gage* a sensor to measure the HS-75 beam strain.
d. *Data logger* as a tool to collect and convert the data from the *Load Cell, LVDT,* and *Strain* gage.
e. Computer as a data storage and data processing.

The Buckling test equipment can be seen in Figure 3, 4, and 5 below:

1. The HS-75 Profile loading model without any Plate Diaphragm.



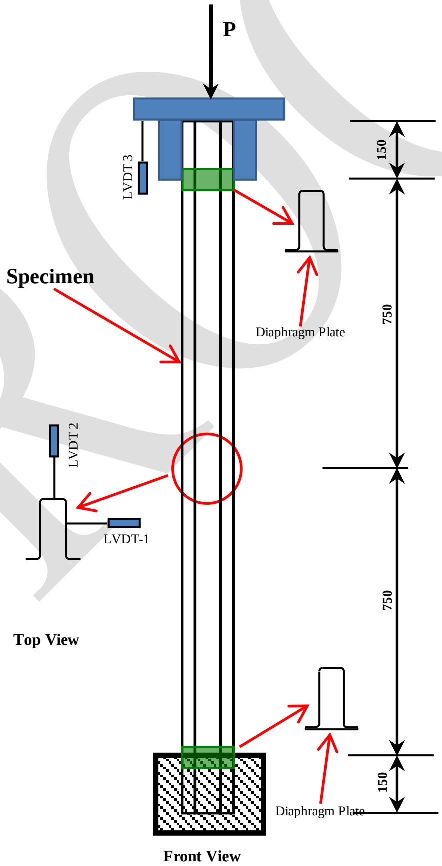


Figure 3. The loading model of a HS-75 profile without a diaphragm plate.

The Experiment Procedure:

a. The first step is to prepare the HS-75 specimen as in Figure 3. A compressive axil load was then given on the free specimen end exactly on the specimen axis position. Two Linear Variable Differential Transducers (LVDT) as a tool gauge to measure the specimen deflection was mounted on 750 mm and 1500 mm from the hinges fixed support end. The strain gauge mounted location is exactly on the middle of the specimen bar object test (750 mm).

b. The next procedure is loading the test bar with a gradual loading *(load control)*. Each stage of loading and displacement (deflection) data were recorded. The load magnitude and bar displacement measured by de load cell and LVDT was also recorded in the data recorder or data logger.
c. These steps were repeated 5 times for every HS-75 specimen.

2. The HS-75 Profile loading model with one Plate Diaphragm attached

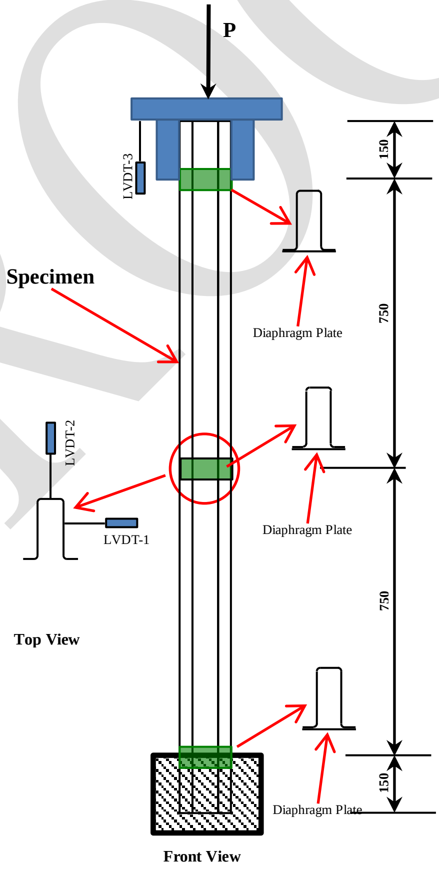
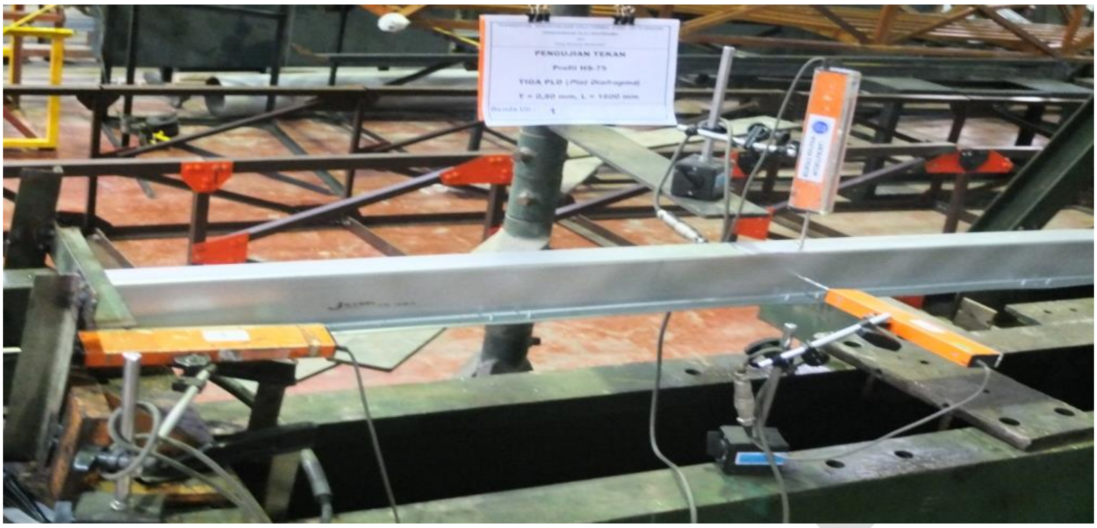


Figure 4. The loading model of a HS-75 profile with one diaphragm plate attached.

The Research Procedures
The testing procedures would mostly the same with the testing procedure in section 3 above. In this case the HS-75 profile was attached with one diaphragm plates positioned 750 mm from the beam fix support.

3. The HS-75 Profile loading model with three Plate Diaphragms attached.



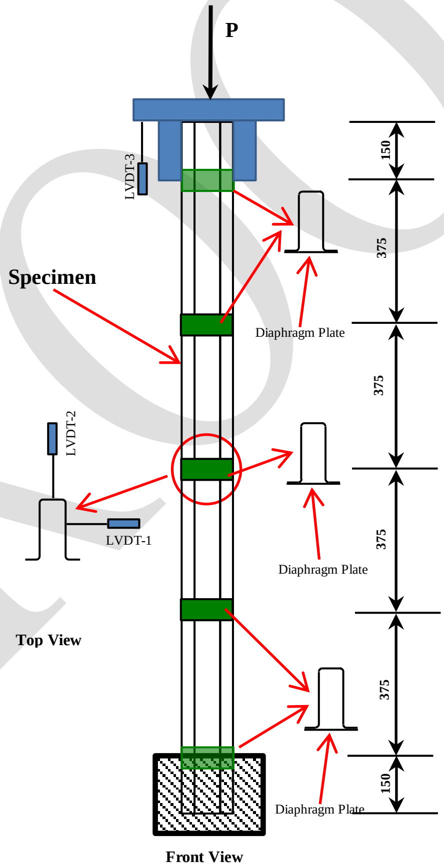


Figure 5. The loading model of a HS-75 profile with three diaphragm plate attached.

The Research Procedures

The testing procedures would mostly the same with the testing procedure in section 3 above. In this case the HS-75 profile was attached with three diaphragm plates. The diaphragm plate was positioned on 375 mm, 750 mm and 1125 mm from the beam fix support.

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Result and Discussion

The buckling strength analysis is based on Figure 6 and figure 7 as follows:

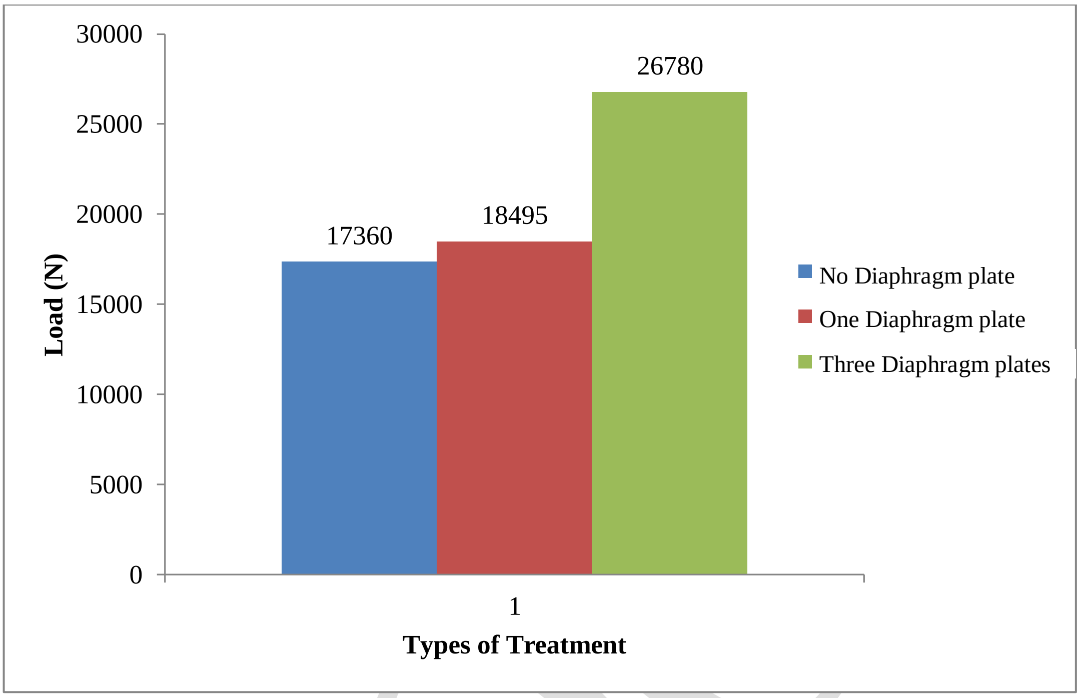

Figure 6. Maximum load on different type of treatments

Based on Figure 6**,** it can be seen that attaching a diaphragm plate would influence the light weight steel strength. Furthermore figure 6 shows that the light weight steel (HS-75 profile) maximum load occurs as big as 26780 N for the profile attached with three diaphragm plate, 18495 N for the profile with one attachment and a maximum load of 18495 N on the profile without any diaphragm load attached. There is an indication that the HS-75 profile with three diaphragm attached was able to withstand a maximum load greater than either the HS-75 profile with one diaphragm plate attached or the HS-75 profile without any diaphragm plate.

This phenomenon appears, of course, because there is an influence by the diaphragm plate attached on the open part of the HS-75 profile. Attaching the diaphragm plate on the open part of the HS-75 profile would increase HS-75 profile stiffness. So that the HS-75 profile has a greater ability to withstand the loads work on the free end beam on the beam axis.

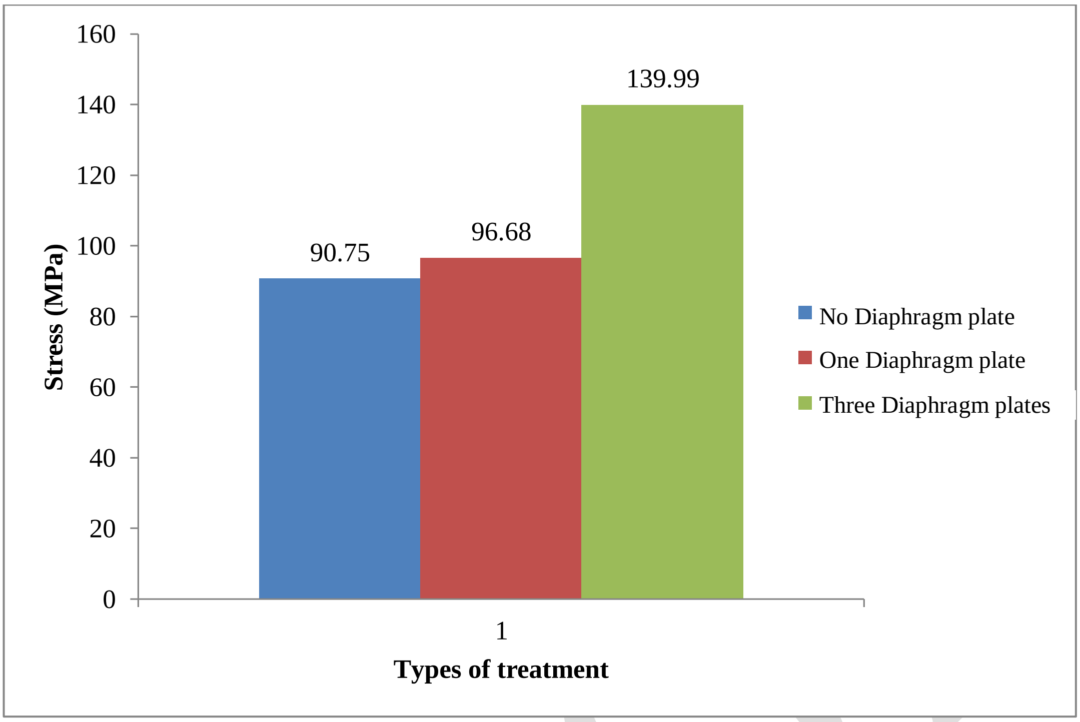

Figure 7. Stress on different HS-75 profile types of treatments

Figure 7 also shows that the stress occurs in HS-75 profile (light steel material) given with three diaphragm plates is bigger (greater) compared either with the stress occurs in the HS-75 with one diaphragm plate or HS-75 without any diaphragm plates. The stress occurs on the HS-75 with three diaphragm plates attached is about 139.99 MPa, about 96.68 MPa for the HS-75 with one diaphragm plate attached and 90.75 MPa for the HS-75 without any diaphragm plate.

CONCLUSION

From the test results and data analysis, it can be concluded that:

1. The HS-75 profile attached with three diaphragm plates has a higher maximum critical load compared either with the HS-75 attached with one diaphragm plate or with the HS-75 without any diaphragm plate attached.
2. The HS-75 profile attached with three diaphragm plates has a greater strength compared either with the HS-75 attached with one diaphragm plate or with the HS-75 without any diaphragm plate attached.
3. The HS-75 profile attached with one diaphragm would induce an increase of the profile strength, but the increasing is not too significant.

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REFERENCES

Acharya, V.V., 1997. Cold Formed Steel Hat Section in Bending with Multiple Intermediate Longitudinal stiffeners. Master Thesis, University of Waterloo.

Acharya, V.V. and Schuster, R.M., 1998. Bending Tests of Hat-Sections with Multiple longitudinal stiffeners. International Specialty Conference on Cold Formed Steel Structures. St. Louis, Missouri, USA.

American Iron and Steel Institute., 1995. Specification for the Design of Cold Formed Steel Structural Members, American Iron and Steel Institute.

Australian Journal of Basic and Applied Sciences, 7(14) December 2013, Pages: x-x

Cold Formed Steel Profile, 2010. Cold Formed Steel In Building Construction. A Catalogue of Company's cold formed profiles producers recommended by the AISI (American Iron and Steel Institute).

Desmond, TP, Pekoz, T., and Winter, G., 1981. Intermediate Stiffeners for thin-walled members. Journal of Structural Engineering, ASCE.

Fang Yiu, Teoman Pekoz., 2006. Design Of Cold Formed Steel Plain Channels. Cornell University Hollister Hall New York.

Hancock, George, J., Murray, Thomas, M., Duane, SE., 2001. Cold Formed Steel Structures To The AISI Specification. Marcel Dekker, Inc. New York.

Jaindo Metal Industries, PT., 2009. A Company profile, produces HS-75 and Industrial roofing, siding, Profile, partitions etc.

Kirsch, Uri., 1981. Optimum Structural Design, Concepts, Methods, and Applications, McGraw Hill Book Company.

Nisshin Steel, Test Laboratory, 2005. A company profile based in Japan.

Renansiva, Revi., 2003. Light Steel as A Glance, PT. Jaindo Metal Industries.

Rogers, C.A., Yang, D., Hancock, GJ., 2006. Stability and Ductility of Thin G 550 High Strength Steel Members and Connections. University of Sydney, Elsevier Science Ltd.

Schafer, B. and Pekoz, T., 1998. Cold-Formed Steel Members with Multiple Longitudinal Intermediate stiffeners. Journal of Structural Engineering, ASCE, 1998.

Setiyono, Harkali, 2008. Investigation of Lightweight Steel Structures Damage Mechanisms. Journal of Science and Technology, BPPT.

Shanmugam, N.E., 2006. Thin Walled Structural Elements Containing Opening. International Conference Thin Walled Structures, Elsevier Science Ltd. The National University Singapore.

Wei Wen Yu, Ph., D, PE, March, 2000. Cold Formed Steel Design. John Willey & Sons, Inc.

Yunus, Ishak, 2008. An Analysis of price comparison between wooden construction with mild steel construction. Student Thesis, lb243 CIPTA HARAPAN.

Zamin, Jumaat and Alam, Md. Ashraful, 2008. Strengthening of R.C. Beams Using Externally Bonded Plates and Anchorages. Australian Journal of Basic and Applied Sciences, 3(3): 2207-2211, 2008. ISSN 1991-8178.